Fu, Qiang, University of Washington

Detecting Atmospheric Trends and Investigating Their Causes

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Abstract: The inconsistency between the satellite-inferred tropospheric temperature trends and the trends near the surface based on in situ observations has long been used to challenge the ability of current global climate models (GCMs) to predict climate changes, the reliability of the observational data used to derive temperature trends, and the reality of human-induced climate change. Recent new analyses of satellite and balloon-borne measurements of lower- and mid tropospheric temperature show warming rates similar to the surface temperature (CCSP 2006; IPCC 2007), largely reconciling a discrepancy noted in previous assessment (NRC 2000; IPCC 2001). However, while new analyses and data are consistent with the results from GCMs at the global scale, discrepancies in the tropics remain to be resolved (CCSP 2006). Furthermore, enhanced mid-latitude tropospheric warming and stratospheric cooling are identified from the satellite observations (Fu et al. 2006), which indicates expansion of tropical circulation. Johanson and Fu (2007) also found unexpected large stratospheric warming over half of the southern hemisphere high latitudes in the winter and spring seasons. Assessment of these changes and investigation of their causes have direct implications to improve our understanding of climate feedback processes (Coleman 2001), poleward shift of subtropical dry zone and thei ncreased frequency of midlatitude droughts (Seidel et al. 2007), and recovery of ozone hole in the Antarctic (Solomon et al. 2005).
The overall objective of our proposed work is to assess atmospheric trend patterns and investigate their causes. We will focus on the vertical structure of tropospheric temperature trends in the tropics, the large stratospheric warming patterns in the southern hemisphere highl atitudes, and the expansion of tropical circulation. We will assess these changes by analyzing multiple satellite datasets along with radiosonde observations and addressing the observational uncertainties in the context of defining the significance of these trend patterns. We will examine the causes of these changes by comparing observations with GCM simulations. A wide range of GCM simulations in support of the IPCC 2007 report, including pre-industrial control runs, 20thcentury experiments with various natural and anthropogenic forcings, and 21st century runs, will be used. In addition, the GCM simulations with prescribed SST and those including good representation of the stratosphere will also be analyzed. As part of our research effort, we will continue to provide a high quality tropospheric temperature product for the climate research. This proposed project will directly contribute to the overall goal of the NOAA Climate Program to improve our ability to observe, understand, predict, and respond to changes in the global environment.